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Patterns, sources and mechanisms of decadal-scale environmental variability in the NEP

Schwing, Franklin B.

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Project Title: Patterns, sources and mechanisms of decadal-scale environmental variability in the NEP
Principal Investigators: Franklin B. Schwing, Richard H. Parrish, Roy Mendelssohn (PFEL), Grigory Monterey (JIMAR), and Tom Murphree (Naval Postgraduate School)

Our project focuses on decadal, interannual, and seasonal ocean variability in the North Pacific using retrospective analyses of atmospheric and oceanic observations. Our first year effort has been mainly creating the physical data bases that are being used in the NEP program by this and other projects. Data analysis and interpretation have been initiated. Preliminary results have been presented at several scientific meetings, and several scientific papers are in preparation. Our current work is focusing heavily on the analysis of the historical oceanic and atmospheric data sets developed and customized in the initial year's efforts. The analysis will concentrate on describing the primary patterns of and mechanisms for seasonal, interannual, and decadal variability in wind forcing and upper ocean fields. Below are some highlights of our NEP work to date.

Created data base system to allow rapid and customized access to the World Ocean Data Base for retrospective climatic change research via Live Access Server (LAS). The implementation at PFEL of the LAS, developed at PMEL, allows users on their own computers to subsample the WODB and other data sets and produce summaries for customized geographic regions in a number of formats that can be read directly into a variety of visualization and analysis software packages. [FIGURES 1-2]. The LAS is available at: http://www.pfeg.noaa.gov/whats_new/las_whats_new.html.

Developed fields of surface and subsurface quantities for retrospective analyses of decadal variability and comparison with model output. Summaries of observed data are being used both for direct analyses of ocean variability and as model validation fields. Global 1° monthly mean surface wind stress fields (from the COADS) and subsurface ocean temperature and salinity fields at standard depths (from the WODB). Monthly climatologies and decadal averages for 1966-75 and 1977-86 have been developed for several fields (e.g., wind stress, temperature, salinity), and have been animated for further analysis. Monthly climatologies and monthly fields can be viewed on the PFEL LAS. [FIGURES 3-4].

Describe annual cycles of primary atmospheric and oceanic quantities based on retrospective analyses and model output. We have used the NCEP reanalysis and COADS wind and SST and WODB temperature fields to describe key aspects of the seasonal cycle and interannual to decadal variability of the NEP. Seasonal climatologies of the observed ocean and atmospheric fields and derivatives of these fields (e.g. wind curl, mixed layer depth) are being analyzed. Seasonal anomalies may be strongly affected by anomalies developed during other seasons. We are comparing oceanic and atmospheric variability within selected subregions of the NEP (e.g. Gulf of Alaska, northern California Current).

Understanding the development of the 1997-98 El Niño – Changes in the North Pacific associated with El Niño (EN) and La Niña events are dynamically similar to decadal scale shifts, so they are very useful analogs of climate change in this region. Atmospheric variations over the NEP were strongly related to the development of the 1997-98 EN in the tropical Pacific. Regional changes in wind stress led to dramatic SST anomalies in the NEP, especially during April-September 1997. Ekman processes driven by anomalous winds played a role in creating the NEP warm pool - a triangular region of relatively warm water between Hawaii, Vancouver Island and Baja California. The first major impacts of the EN on the NEP did not commence until November 1997. These insights suggest new ways to monitor climatic changes that may affect marine populations in the NEP. [FIGURES 5-6].

Comparing decadal differences in wind-forced circulation of the North Pacific – At mid-latitudes in the North Pacific, zonal winter wind stress doubled in the decade following the 1976 climate shift, leading to increases in several derived ocean variables: southward Ekman transport; upwelling due to Ekman pumping; turbulent mixing; and total poleward and zonal transport. Transports of the North Pacific Current and the subtropical gyre increased. All of these modifications are likely to be associated with significant changes in the advection and distribution of heat, nutrients, and organic material throughout the basin. [FIGURES 7-8].

PUBLICATIONS FROM THIS PROJECT:

Mendelssohn, R., F. Schwing, C. Roy, and R. Parrish. Common and Uncommon Trends in Oceanic Parameters off South America, unpubl. ms.

Murphree, T. and F. Schwing. Extratropical factors affecting the evolution of the 1997-1998 El Niño, unpubl. ms.

Murphree, T. F. Schwing, and L. DeWitt. Multiple wave trains and the analysis of climatic teleconnections during El Niño and La Niña events, unpubl. ms.

Schwing, F. and T. Murphree. The Northern Oscillation Index (NOI): a climate index for the northeast Pacific, unpubl. ms.

Monterey, G. and L. DeWitt. 1998. Seasonal to interdecadal variability of the North Pacific circulation based on the climatological data and the Princeton Ocean Model. EOS 79(1): OS72.

Monterey, G. and L. DeWitt. 1998. Seasonal cycle of the North Pacific circulation based on the climatological data and the Princeton Ocean Model. Proceedings of the Princeton Ocean Model Users Meeting, Rosenstiel School of Marine and Atmospheric Science, Miami, 32 pp.

Murphree, T. and F.B. Schwing. 1998. Tropical–Extratropical Interactions in the North Pacific Region During the 1997-1998 El Nino. EOS 79(1): OS73.

Murphree, T. and F.B. Schwing. 1998. The origins and impacts of the 1997-1998 El Nino. EOS 79(45): F522.

Parrish, R.H., F.B. Schwing, and R. Mendelssohn. 1998. Shifting Mid-latitude Winds: A Mechanism for Decadal Climate Change in the North Pacific. EOS 79(1): OS72.

Schwing, F.B. 1998. Patterns and mechanisms for climate change in the North Pacific: the wind did it. In: Proceedings, ‘Aha Huliko’a Hawaiian Winter Workshop, (G. Holloway, P. Müller and D. Henderson, eds.) SOEST Special Publication, University of Hawaii at Manoa, Honolulu, HI. pp. 29-36.

Schwing, F. B., P. Orton, D. A. Jay, H. Batchelder, and L. K. Rosenfeld. 1999. Conference Explores El Nino's Relationship to the Northeast Pacific. EOS 80: 122-127.

ADDITIONAL SCIENTIFIC PRESENTATIONS FROM THIS PROJECT:

DeWitt, L. and R. Mendelssohn. Accessing and Visualizing Archived and Near Real-Time Data Sets

for Monitoring Oceanographic Change. CalCOFI Conference, November 1998, Pacific Grove, CA.

Brodeur, R., P.T. Strub, F. Schwing, M. Ohman and H. Batchelder. Retrospective data analysis in the US GLOBEC Northeast Pacific (NEP) program. PICES, October 1998, Fairbanks, AK.

DeWitt, L. and R. Mendelssohn. Accessing and Visualizing Archived and Near Real-Time Data Sets for Monitoring Oceanographic Change. Eastern Pacific Ocean Conference, September 1998, Mt. Hood, OR.

Murphree, T. and F.B. Schwing. The evolution and impacts of the 1997-1998 El Nino. Eastern Pacific Ocean Conference, September 1998, Mt. Hood, OR.

Schwing, F.B. and T. Murphree. Anomalous ocean conditions in the Northeast Pacific, 1997-1998: El Nino or not?. Eastern Pacific Ocean Conference, September 1998, Mt. Hood, OR.

Schwing, F.B. Time Series: New Methods, Fisheries and the Environment. Alaska Fisheries Science Center, Seminar Series, February 1999, Seattle, WA.

FIGURES

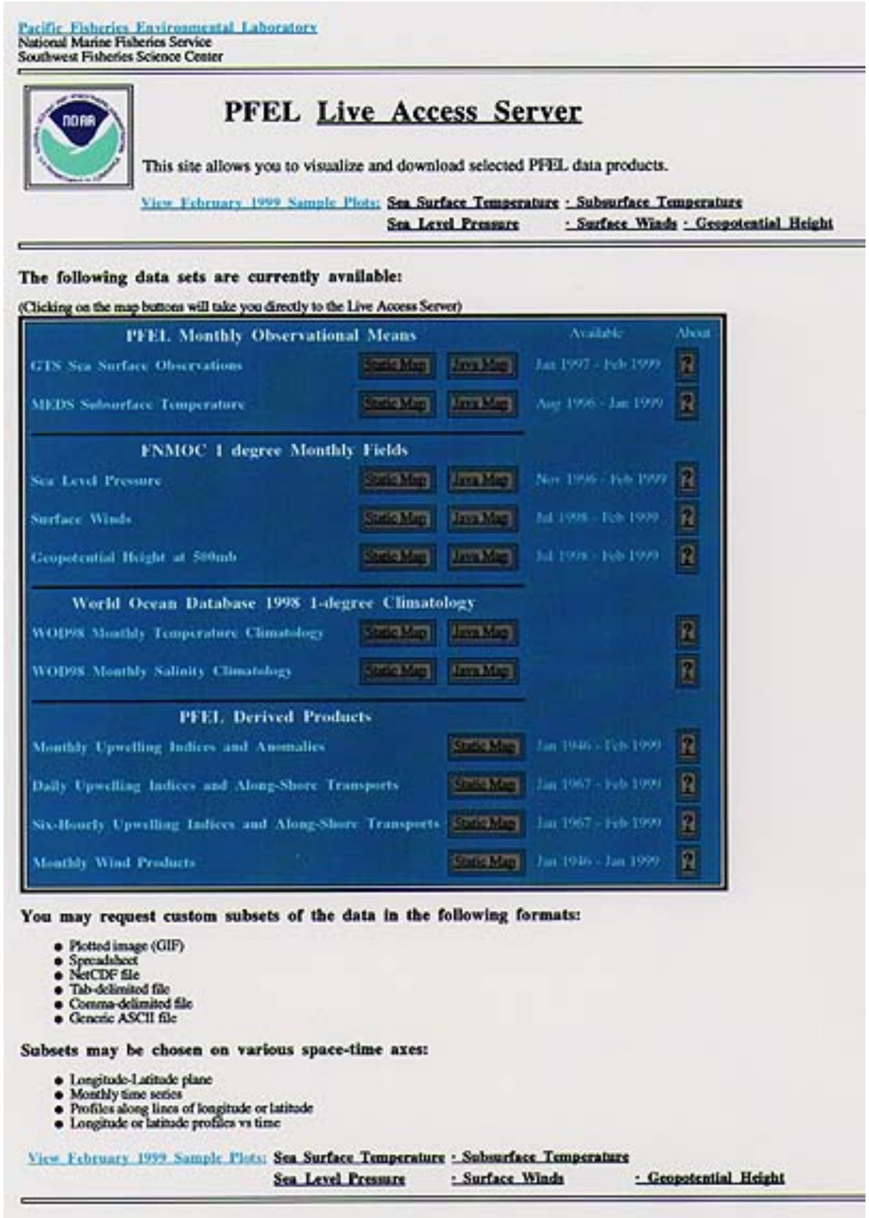


FIG. 1. Users entering the PFEL Live Access Server (LAS) will get this image, which allows access to the data sets shown. This front end shows the data sets or products and the period they are available. Information about the data set can be viewed by pressing the "?". Users also can view the most recent monthly global images of several fields (example is Fig. 4).

The URL for the LAS is http://www.pfeg.noaa.gov/whats_new/las_whats_new.html

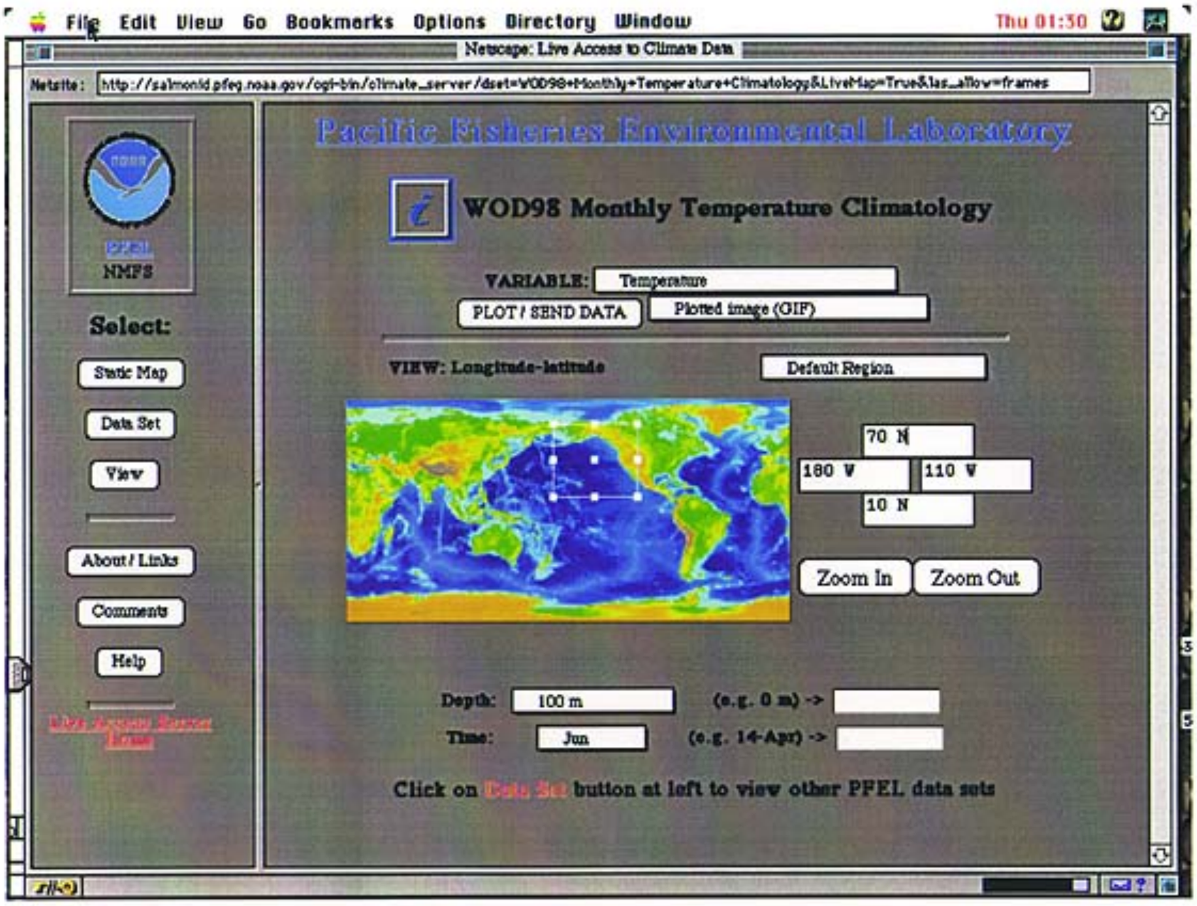


FIG. 2. Users selecting a Static Map or Java Map option for one of the data sets will receive an image similar to this. Options allow the user to select the variable, format, geographical region, depth (if applicable), and time. The user also can change the data set, and view by lines (e.g. depth profile, time series), planes (e.g. long-lat, depth-time), and volumes (e.g. long-lat-depth).

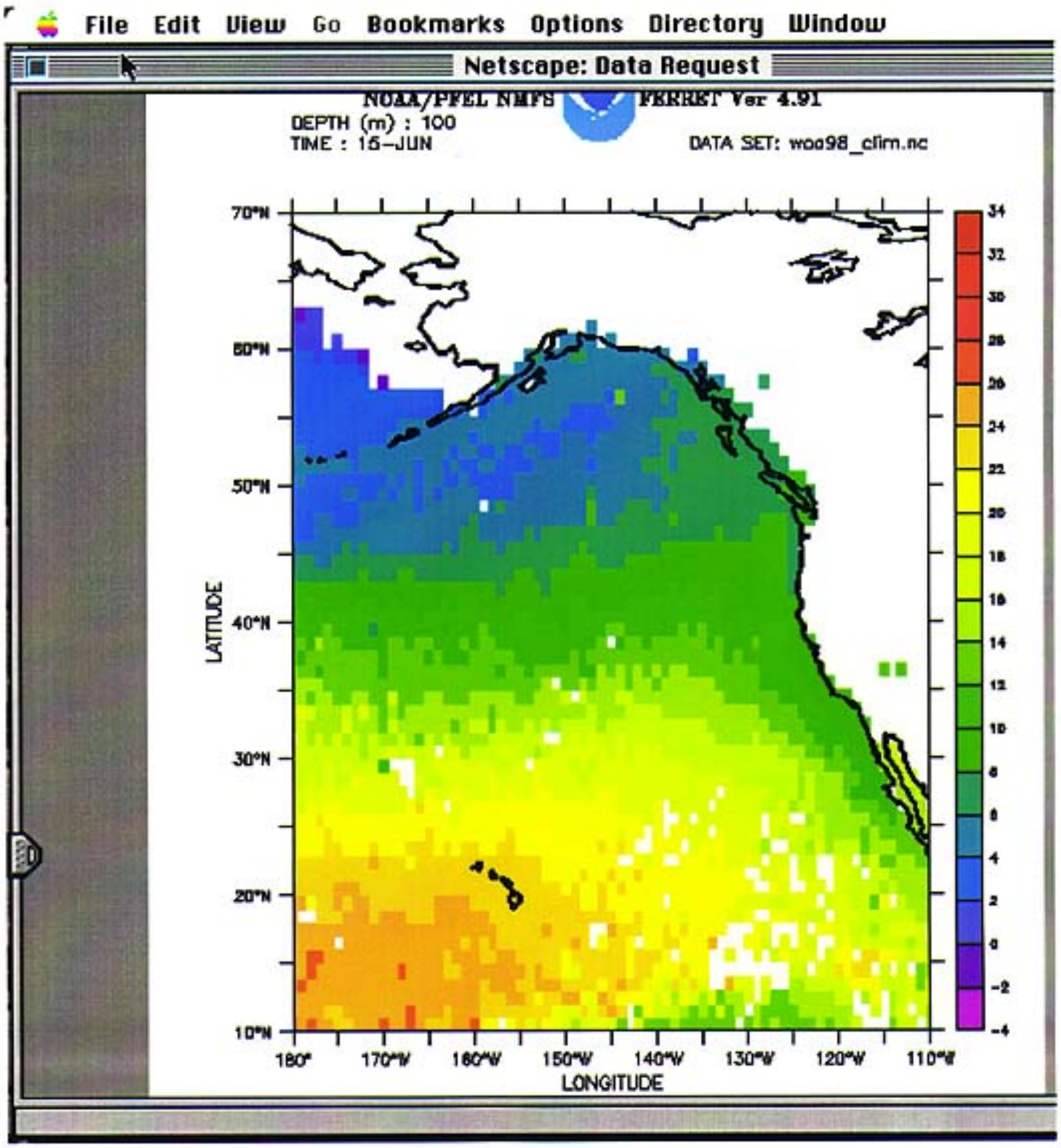


FIG. 3. Pressing the "PLOT/SEND DATA" button will display a map image similar to that shown here, or a list of the data, depending on the user's request. Shown is the June climatology of 100m temperature for the NEP.

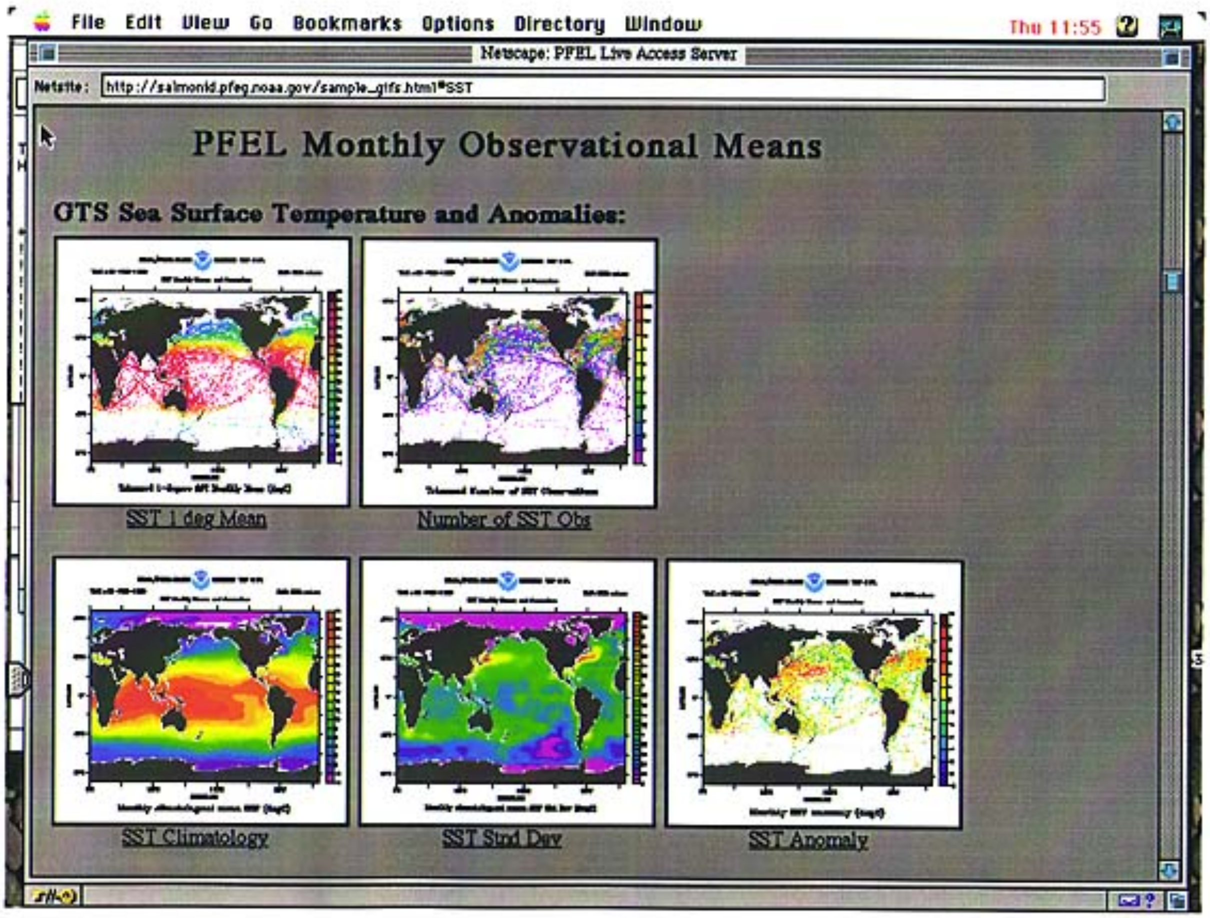


FIG. 4. This is an example of some of the updated monthly global summaries available via the PFEL LAS. These maps are based on the February 1999 data and the February monthly climatologies. Updates are available a few days after the beginning of the month.

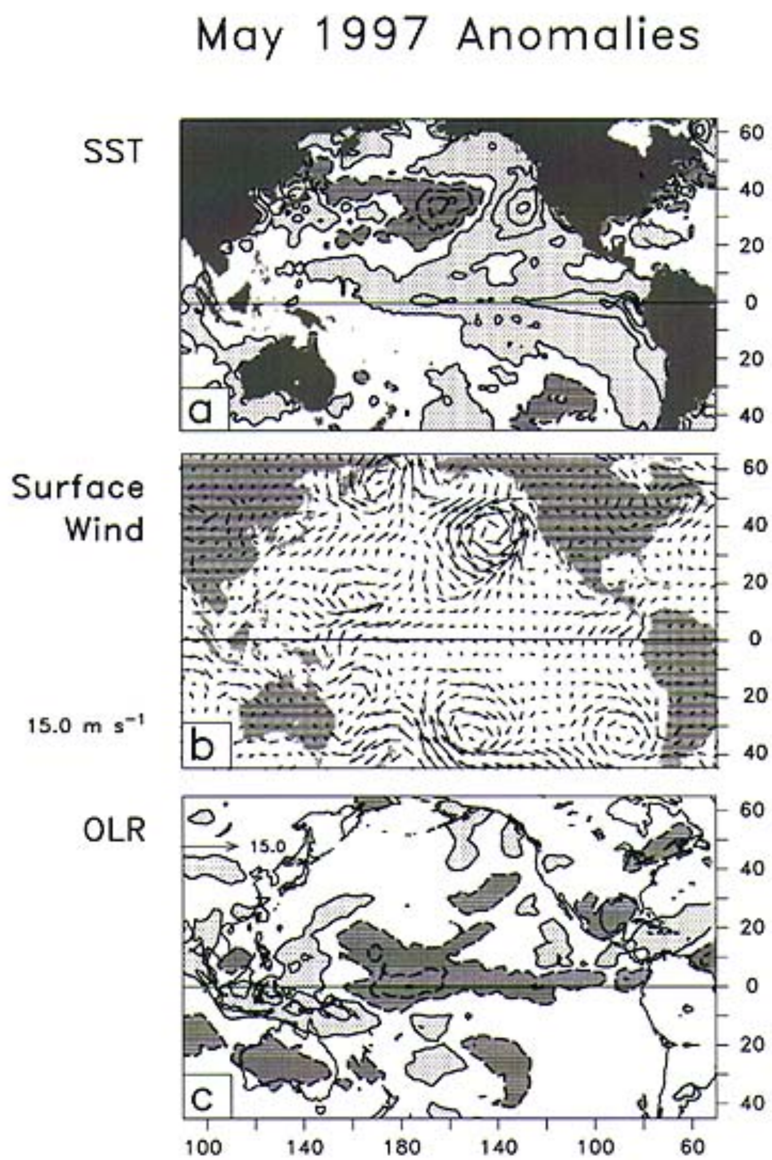
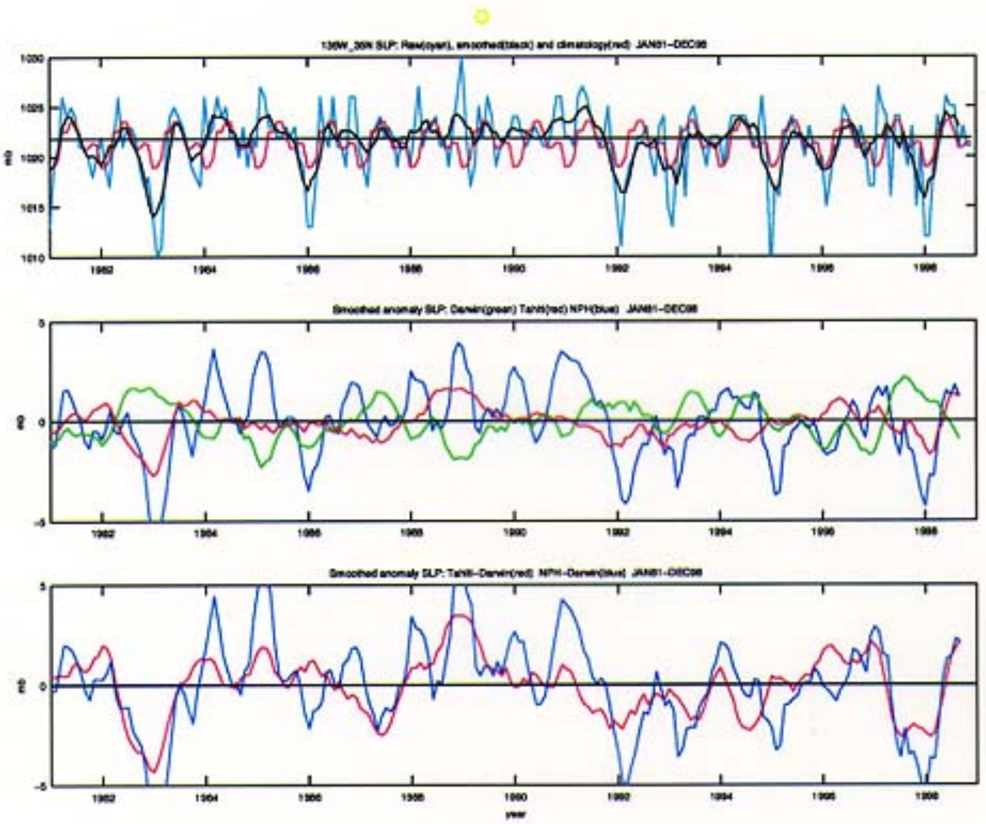


FIG. 5. Monthly anomalies of SST, surface wind velocity, and outgoing long-wave radiation (OLR, a proxy for atmospheric convection) for the Pacific during May 1997. Positive (negative) anomalies are hatched (shaded). An unusually weak North Pacific High led to anomalous cyclonic winds in the NEP and were associated with weaker trades extending into the western equatorial Pacific. The anomaly of the curl of the wind stress (not shown) displays a pattern similar to, and consistent with, the SST anomalies. Positive (negative) SST anomalies were overlaid by negative (positive) curl, which presumably resulted in less (greater) Ekman pumping. Anomalies of subsurface temperature (not shown but similar to Fig. 8) are consistent with this idea that ocean anomalies in early 1997 were due to regional atmospheric anomalies rather than tropical El Niño processes.



UPPER PANEL-

Monthly averaged SLP in a 2° square centered at 35°N 135°W, 1981-1998 (North Pacific High), shown in blue.
Five-month running smoothed version of series (black).
Climatology of series for period shown (red).

MIDDLE PANEL-

Five-month smoothed SLP anomaly of NPH relative to climatology (blue).
Smoothed SLP anomalies at Darwin (green) and Tahiti (red).

LOWER PANEL-

NOIx (blue), computed as difference between NPH and Darwin SLP anomalies.
SOI (red), computed as difference between Tahiti and Darwin SLP anomalies.

FIG. 6. Derivation of extratropical Northern Oscillation Index (NOIx), an index analogous to the SOI. The NOIx was developed to provide a time series that integrates physical variability in the North Pacific. Shown here are the monthly time series of sea level pressure (SLP) at 35°N 135°W, the approximate center of the North Pacific High (NPH) for 1981-1998 and its climatology (upper panel); the SLP anomaly of the NPH compared to SLP anomalies at Darwin and Tahiti, the series contributing to the SOI (middle panel); and the NOIx (NPH-Darwin) and SOI (Tahiti-Darwin) time series (lower panel). The lower panel reflects similarities as well as differences in the SOI and NOIx. Both series show the major El Niño (negative) and La Niña (positive) events, but the amplitude and timing differs between the two. The NOIx identifies La Niña events more strongly, and may generally better reflect variability in the NEP than the SOI. These series are being compared from 1951, and with a number of other physical and biological time series in the NEP.

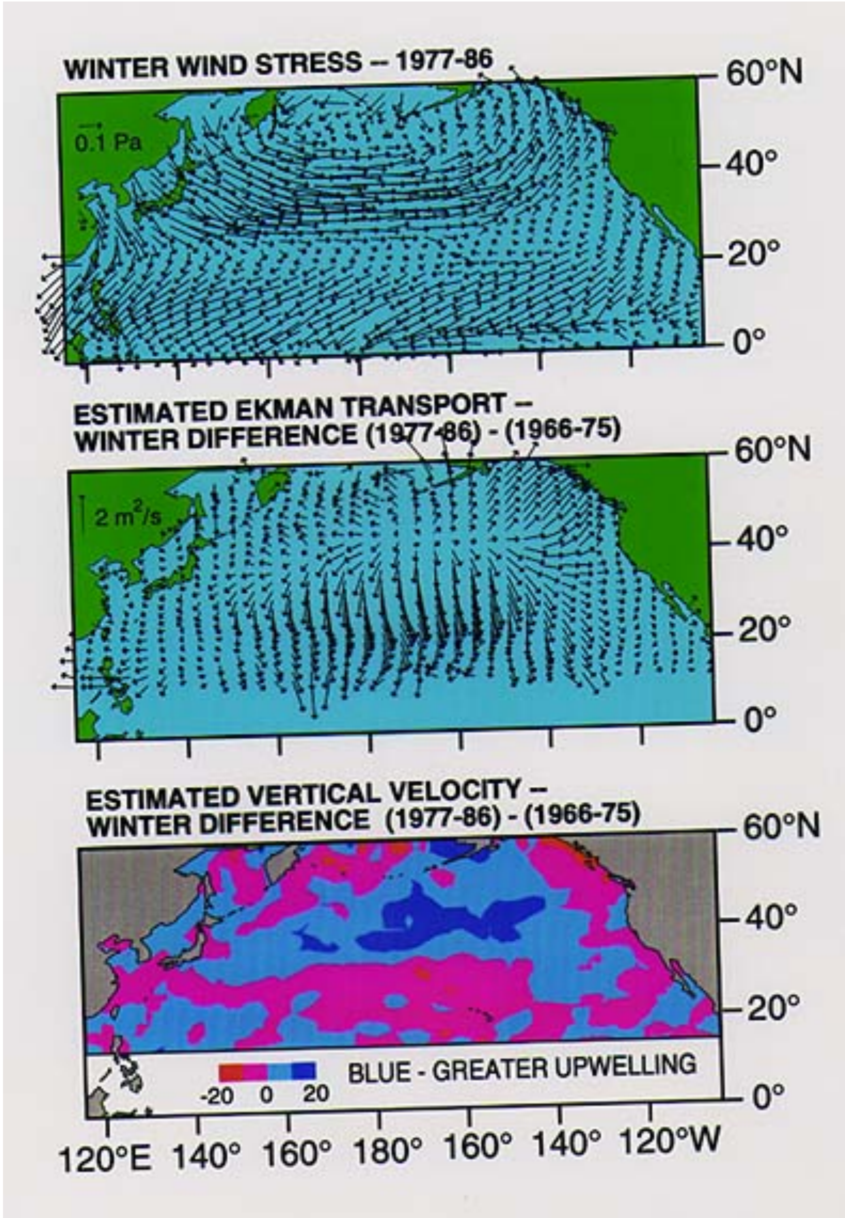


FIG. 7. a) Winter (DJF) mean wind stress over North Pacific, averaged for decade 1977-86. Compared to decade average for 1966-75, stress was greater across central North Pacific (30-40°N), and more northward directed in NEP. b) Change in Ekman surface transport, estimated from difference in winter wind stress during 1977-86 less 1966-75. Surface transports became more southward (northward) south (north) of 40°N, and increased into Gulf of Alaska and toward the west coast. c) Change in vertical velocity (upwelling), estimated from divergence in Ekman transport (center panel). Blue (red) shades denote areas of relatively greater (less) upwelling. The pattern suggests an increase in winter upwelling over a large area of the central North Pacific and Bering Sea, but less winter upwelling in the eastern Gulf of Alaska and southern California Current.

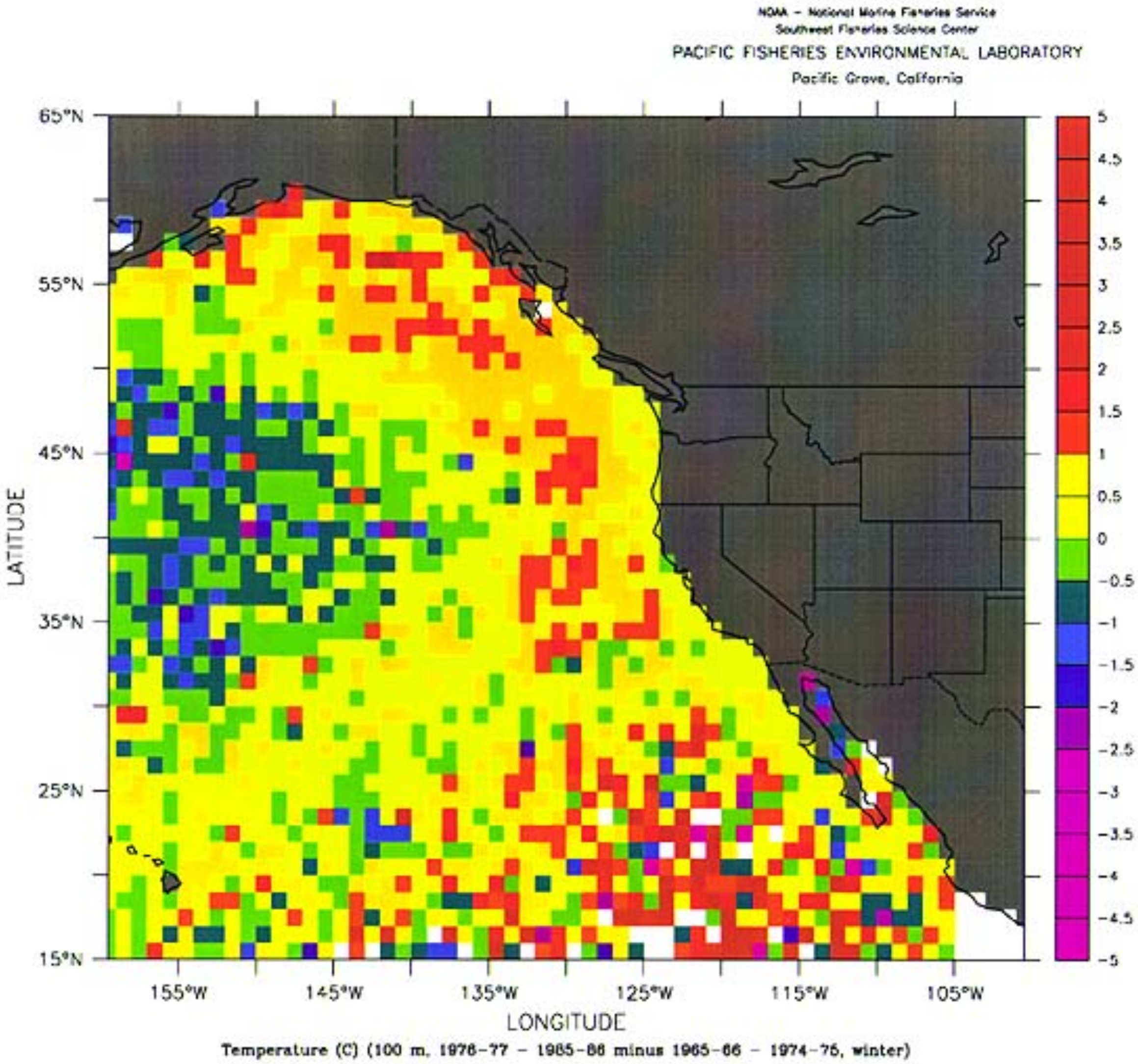


FIG. 8. Decadal difference in winter temperature at 100m, 1977-86 less 1966-75. Red/orange denotes relatively warmer; blue denotes relatively cooler. The pattern of cooling in the central North Pacific and warming around the basin periphery corresponds with the pattern of upwelling estimated from Ekman divergence. It also is very similar to the temperature anomaly field observed during the 1997-98 El Niño.